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ABSTRACT

Piaget's studies clearly highlight two qualitative advances made during the preoperational period. The first is the breakthrough of representational intelligence, beginning around 2 years of age. The second is the emergence of coordinated representational thought, beginning around 4 years of age. This paper focuses on the second advance, which Piaget calls the "intuitive substage." The paper begins with a summary of intuitive thought as conceived in the classical Genevan studies of the 1940s and 1950s, then moves to the more detailed analyses provided in three relatively recent sources: (1) the research on the psychology of functions; (2) studies of possibility and necessity; and (3) research on the logic of meaning. These analyses elaborate on the logical structure of intuitive thought and describe the emergence of logical modalities and the abstraction of representational meanings during the intuitive period. It is concluded that these Genevan accounts of the transition at 4 years of age are consistent with current research and theory in such areas as children's theories of mind, and children's understanding of certainty and probability, and of appearance and reality. (RH)

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Genevan Contributions to Characterizing the "Age 4 Transition"

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RUNNING HEAD:

The Age 4 Transition

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ABSTRACT

Although it became commonplace a few years back to view Piaget's theory as underestimating the competence of young children, his studies clearly highlight two qualitative advances during the preoperational period. Foremost is the breakthrough of representational intelligence, beginning around 2 years. Second is the emergence of coordinated representational thought, beginning around age 4. This second period from 4 through 6 years, which Piaget calls the "intuitive substage," is the focus of this paper.

After summarizing the description of intuitive thought as found in the classical Genevan studies of the 1940's and 1950's, the paper focuses on the more detailed analyses provided in three more recent sources: The research on the psychology of functions (Piaget et al., 1968/1977) elaborates the logical structure of intuitive thought; the studies of possibility and necessity (Piaget 1981/1987a; 1983/1987b) describe the emergence of logical modalities during the intuitive period; and the research on the logic of meaning describes the abstraction of representational meanings during this period. It is concluded that these Genevan accounts of the age 4 transition are consistent with current research and theory in such areas as children's theories of mind, understanding of certainty and probability, and understanding of appearance and reality.

Genevan Contributions to Characterizing the "Age 4 Transition"

During the 1940's and 1950's, Piaget and his colleagues produced a stream of classical studies on children's concept development in areas such as number, logic, space, time, and so forth. These studies always distinguished two substages in the period between 2 and 7 years: The earlier one, from 2 to 4 years, is generally called the preconceptual or transductive substage; the later one, from 4 through 6 years, is called the intuitive substage.

Early Descriptions of Intuitive Thought

These classical studies describe a great variety of new conceptual achievements beginning around age 4. For example, in the domain of number, Piaget notes the emerging notion of one-to-one correspondence and the beginning of systematic counting and ordering (Piaget & Szeminska, 1941/1952). In the domain of logic, children begin to classify by means of stable sets rather than by graphic collections (Inhelder & Piaget, 1959/1964). Similar examples can be given from other domains. What they have in common is that mental representations are no longer static and subordinate to external actions. Representations are now becoming coordinated into systems of thought --although these systems still work by trial and error, with a great deal of dependence on perceptual cues and on overt actions with objects.

The basic metaphor behind the label "intuitive" is that children are capable of various forms of correct reasoning, but without understanding the justification or the necessity of their reasoning. Consequently, the

intuitive child's thought remains somewhat unstable and unreliable. For example, this is the period when children may answer a conservation question correctly, but then change their minds when they are given a countersuggestion. Notice the implication that intuitive thought should be quite adequate under most ordinary circumstances. Intuitive thought is not conspicuously less adequate than concrete operational thought, except under frankly challenging conditions. For example, intuitive thought reveals its lack of rigor under conditions when perceptual cues happen to be very misleading, or when another person intentionally questions and probes the child's opinion. This is worth pointing out because of an impression that seems to have become popular a few years ago, that Piaget ignored or devalued the competencies of preoperational children.

In fact, the classical studies of the 40's and 50's highlight the positive features that distinguish the intuitive period from the preconceptual period, just as they highlight the positive features that distinguish preconceptual thought from sensorimotor intelligence. Nevertheless, there is no doubt that Piaget's primary objective in these studies is describe children's acquisition of mental operations, at about age 7. Operations express a completely new form of logical necessity, which means that thought becomes more stable and reliable under a wider range of conditions. From this vantage point, the significance of intuitive thought is that it obviously foreshadows and prepares the way for the emergence of concrete operations.

For a developmentalist, to say that a period is preparatory or transitional does not make it less important than what follows. Rather, a transitional period is interesting because it expresses processes of

equilibration and construction, and the period that follows is interesting because it expresses forms of stability and equilibrium. Throughout the studies of the 40's and 50's, Piaget analyzes intuitive reasoning carefully, looking for clues about the constructive processes that lead to operations. However, most of his explanations are fairly global. For example, he suggests that intuitive reasoning first succeeds by going stepwise from one thought to another; gradually, intuitive structures begin to combine these thoughts simultaneously, and to consider the reverse combinations; eventually this leads to stable operational structures (cf., Piaget & Inhelder, 1948/1956, p. 454). This sort of explanation is reasonable, but incomplete.

Elaborations on the Nature of Intuitive Thought

For more detailed explanations about the nature of intuitive thought, we need to look at the later studies from the 1960's and 70's. A lot of the work Piaget did during his last two decades doesn't seem to be as well known as the earlier work. I will focus on three sources from this period: First, the studies on the Psychology of Functions (Piaget, Grize, Szeminska, & Vinh Bang, 1968/1977), which delineate the unique logical structure of intuitive thought. Second, the two volumes on Possibility and Necessity (Piaget, 1981/1987a; 1983/1987b), which trace the emergence of logical modalities to the intuitive period. And third, the research on the Logic of Meanings (Piaget, 1987/1991), which describes intuitive thought in terms of the abstraction of representational meanings.

The Structure of Intuitive Thought. The work on the psychology of functions continues Piaget's longstanding interest in formal models, and it is the first time he identifies a specific model to capture the unique

strengths and weaknesses of the intuitive stage. The formalism he uses is mathematical category theory (MacLane, 1971). In mathematics, category theory is important because it is a general theory of mathematical structure, which makes possible a precise study of similarities and differences among structures. An introduction to category theory is beyond our present scope (but can be found in Davidson, 1988). The important point for present purposes is that the concepts of category theory are very general, as well as precise. For example, category theory applies equally well to structures that contain reversible binary operations, and to those that do not. This is the reason category theory could be used by Piaget to formalize the quality he had always ascribed to intuitive structures--a systematic logic without reversible operations.

The basic elements in a category-theoretic definition are functions, or mappings; accordingly, Piaget's model defines intuitive thought as a system of mappings. There are basically two ways this definition has been used to analyze children's thinking. One way is to design tasks based on mappings, and study children's developing ability to solve them. The idea of mapping involves a family of related concepts such as ordered pair, composition of mappings, finding the inverse of a mapping, and so forth. The book on functions (Piaget et al., 1968/1977) contains numerous examples of tasks designed to assess children's ability to use concepts such as these in the context of concrete, manipulable materials. The general finding is that children begin to evince these mapping notions, in rudimentary form, around 4 years of age. Thus, the intuitive period is now frequently referred to as the "stage of functions," just as the period after 7 years is identified with concrete operations.

Second, mapping notions have also been used to reanalyze the structure of classical cognitive tasks. For example, hierarchical class inclusion can be seen as a system of many-to-one mappings, and conservation can be seen as a structure preserving mapping, or morphism. Such interpretations, based on category theory, can in fact be applied to any cognitive task. The significance of this is that Piaget now has a general theory of cognitive structure, which makes possible a precise study of similarities and differences between cognitive structures, from sensory motor schemes through formal operations.

With respect to the age 4 transition, the significance of the new formalism is to clarify the similarities and differences between intuitive thought and preconceptual thought, on the one hand; and between intuitive thought and concrete operations, on the other. In other words, Piaget's 1968 model specifies how the structures of each stage would need to be extended in order to transform them into structures of the next stage (Davidson, 1988).

Intuitive Thought and the Opening of Possibilities. Piaget had always recognized that a structural account alone is insufficient to explain development, and sought to balance his structural approach, largely influenced by contemporary mathematics, with a process approach, largely influenced by contemporary biology (e.g., Piaget, 1936/1952). Having advanced the new category-theoretic model of cognitive structure, Piaget set out to amplify his process model. The book on Equilibration (Piaget, 1975/1985) deals extensively with development from a procedural point of view. However, Piaget also argues that an account of equilibration alone is not sufficient to describe the constructive

process. A still more basic developmental process is the "opening of possibilities." This is the main focus of the second source I mentioned above: the recent work on Possibility and Necessity.

Consider the entire progression of representational intelligence, beginning at the end of infancy and extending into adulthood. The initial state is one of nondifferentiation between reality, possibility, and necessity. Reality is perceived as being necessarily "the way it is," so that it constitutes the only possibility. As long as representational thought is tied to what it takes to be the given state of affairs, there is no chance of forming new interpretations, new mental combinations, or new cognitive structures to organize these combinations. Therefore, development must involve a progressive differentiation of reality, possibility, and necessity, until reality ultimately becomes subordinated to deductive systems of possibilities.

The new work on possibility and necessity is significant as Piaget's most complete account of novelty--the origin of new elements of thought. Obviously, novelty in general and the origin of mental operations in particular are closely connected questions. Upon reading Piaget's earlier work, one sometimes has the impression that the operations originate mysteriously, and then they are used to account for all other psychological phenomena. But here is what Piaget says now:

> The development of operational structures is a consequence of another, more general evolution that cannot be explained in terms of operational development only. Operations require, in fact, a synthesis of possibility and necessity, the former characterizing their procedural freedom (flexibility), the

> latter their self-regulation and their system-bound compositions. (Piaget, 1981/1987, p. 149).

With regard to the age 4 transition, the significance of this new work is that the first steps in the opening of possibility occur at the beginning of the intuitive substage. For example, when children are given a problem of finding the possible routes of a toy car from point A to point B, the younger ones can't get away from the idea of a single, most direct path that must be correct. On the other hand, intuitive children easily produce a number of genuinely different possible solutions, although they are limited to step-by-step and perceptually-based strategies. In short, intuitive children begin to see that a given reality could be otherwise, and that their own actions involve choosing between different possible courses.

Intuitive Thought and the Abstraction of Meaning. Although Piaget believed he had brought to light a more basic process than either equilibration or operations, he was not satisfied, but turned to ask a still more basic question: How do children construct meaning itself? In order to understand how children perceive new possibilities in reality, and invent new possible ways of acting on reality, we need to understand how children attribute meanings to objects and actions. This brings me to the third source I want to highlight, the research on the Logic of Meanings (Piaget, 1987/1991).

The purpose of this book is to ground operatory logic in the meanings of actions. This proposal about the source of logic is not new in Piaget's epistemology, which had always been thoroughly constructivist. But Piaget was eager to ground his epistemology on more unambiguous

interpretations of both cognitive structure and cognitive process. In the first place, his earlier descriptions of operatory logic had not been thoroughly grounded in the subject's constructions; instead, they were heavily dependent on existing mathematical and logical formalisms. Piaget realized this might leave his theory vulnerable to the claim that logical development depends on the internalization of structure from preformed external sources (e.g., via linguistic influences). In the second place, his equilibration model is heavily dependent on biological notions; Piaget realized this might leave the theory vulnerable to the claim that development can be reduced to some hereditary mechanism.

The new work on the logic of meanings finally provides what Piaget aimed for all along--a theory of how logic is derived directly from the subject's actions. The key is Piaget's analysis of the implications between meanings. As he says,

> If all truth is based on meanings, and if all forms of meanings consist in attributions of schemes to either predicates, objects, or actions, then clearly there could be no such thing as an isolated scheme or meaning. Rather, there are always multiple relations among them. This means that at all developmental levels, no matter how primitive, all knowledge has an inferential dimension, however implicit and elementary it may be. To put it another way, using a meaning always presupposes and entails using some implications....
>
> The import of this definition of 'meaning implication' is that, since any action, in addition to its causal aspect (i.e., its actually being carried out) has a meaning, there must be

> implications between actions, that is to say between their meanings. This is a fundamental reality, going far beyond the realm of implications between statements, and manifested from the beginning of what we have called the logic of actions, which is the necessary basis of operatory logic. (Piaget, 1987/1991 [Part I Conclusions]).

To clarify what Piaget means by "implications" in this context, here's an excerpt from one of his analyses of a specific task:

> To reach an object implies getting closer to it, and to push it implies continuing this "going toward" movement; whereas to pull back would imply a movement in the opposite direction, hence its greater difficulty. To sweep laterally implies a shift from the "toward" direction to the perpendicular; hitting the board implies that a positive outcome is possible; and so on .... This accounts for the presence, at this very first level, of proactive and retroactive implications. (Piaget, 1987/1991 [Chap. 1]).

To summarize, Piaget's point is that all actions have some meaning for the subject, and all meanings directly entail a system of implications. Therefore, the meanings constructed by the subject intrinsically contain the necessary and sufficient conditions for the eventual elaboration of inferential systems (including concrete operations and formal operations, as Piaget tries to demonstrate).

As I mentioned, the significance of this book is to fulfill Piaget's project of explaining the origin of all logic in the subject's constructive activities, without relying in any essential way on the

properties of systems borrowed from formal logic. The new theory is also more comprehensive than the earlier accounts, in that it organizes all logical development, up through formal operations, in one simple design, with its roots firmly in the sensorimotor period.

To give a concrete example from this research on meanings, in one task children are asked to retrieve toys from behind barriers. The toys are too distant to reach by hand, so children have to use tools that are provided, such as rods with a hook at the end. The finding is that 4-year old children solve such problems, whereas 2- and 3-year olds do not. The children's reactions make it clear that the 2- and 3-year olds understand the task, but for these subjects the meaning of the tools is too global. In fact, the objects do not have a meaning of "tool" at all, and the children do not try to use them as tools. On the other hand, for the 4-year olds, the objects have detailed meanings: a rod means something that can reach, a hook on the end of a rod means something that can grasp and hold, and so forth. In short, for these subjects, the objects have a meaning of "tool."

This illustrates the progress that 4-year olds have made in understanding the meanings of their own actions such as "reaching," "grasping," and "holding," to the extent that these meanings can now be attributed to external objects such as rods and hooks. Notice that two year olds may very well have the ability to <u>represent</u> their own action such as reaching, in the sense of having a mental image of it. What we are talking about here is an ability that goes beyond this--the ability to abstract the <u>meaning</u> of the action, or of a figural representation. It is the abstraction of meanings from actions that makes thought mobile.

Abstracted meanings can be moved from one mental context to another, unlike the literal actions of an infant or the static representations of the 2- and 3-year old.

Conclusion

I have summarized a number of contributions that Genevan research has made toward understanding the cognitive breakthroughs that occur around age 4. First, the earlier work provides general descriptions of how intuitive thought is qualitatively more accurate than preconceptual thought, yet less rigorous than concrete operational thought. Later, Piaget gives a more systematic structural account of these stage differences. Finally, there are more recent descriptions of intuitive thought in terms of fundamental processes such as opening up possibilities, and abstracting meanings.

In conclusion, I would suggest that this last point, about the abstraction of meanings, might be a good focal point for linking the Genevan contributions to other theories of the age 4 transition. Specifically, to abstract the meaning of a representation can be viewed as a second-order representation. And, in a general sense, having a second-order representational capacity is equivalent to a kind of reflection on one's knowledge. This interpretation is consistent with the current research that finds a variety of reflective capacities emerging around age 4. For instance, second-order representation is probably implicated in children's emergent theories of mind, and in recognizing mental states such as deception. It would be implicated in understanding the difference between reality and appearance. And it would also be implicated in understanding modalities of thought, such as degrees of

certainty in one's judgments. Each of these topics constitutes an active area of research with young children.

Certainly, much of the recent interest in these abilities has arisen independently of Piaget's theory of the intuitive stage. In light of this, the convergence toward a common conception of the age 4 transition is all the more compelling.

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